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**WATER QUALITY CONTROL STUDY SUN-TETON
UNIT MONTANA. STUDY OF POTENTIAL NEEDS
AND VALUE OF WATER FOR THE PURPOSE OF
WATER QUALITY CONTROL OF THE SUN-TETON
UNIT, MONTANA**

**Federal Water Pollution Control Administration
Denver, Colorado**

July 1966

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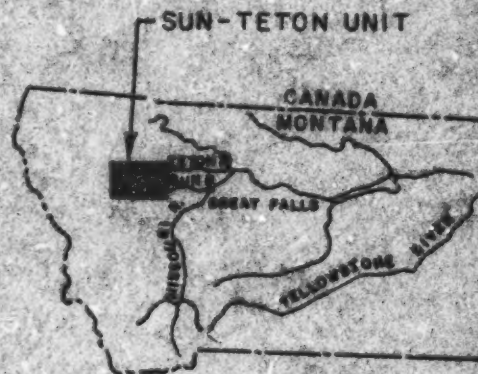
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WATER QUALITY CONTROL STUDY

SUN-TETON UNIT MONTANA

Study of Potential Needs & Value of Water
for the Purpose of Water Quality Control of the
Sun-Teton Unit, Montana



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WATER QUALITY CONTROL STUDY

SUN-TETON UNIT MONTANA

ABSTRACT

A survey was made of the Sun River and Teton River Basins, which showed that the waters of the Sun River are of excellent quality for the proposed uses; the waters of the Teton River, however, show a marked deterioration in quality downstream of Choteau, Montana. The construction of the project at either one of three tentative sites is not expected to significantly impair water quality of the Sun River for its proposed uses. Based on the available water quality data and the anticipated effects of project development on water quality, no need is foreseen at this time for the inclusion of storage for the purpose of streamflow regulation for water quality control.

Prepared at the request of and in cooperation with the
Bureau of Reclamation, Region 6, U. S. Department of the
Interior, Billings, Montana

United States Department of the Interior
Federal Water Pollution Control Administration
Denver, Colorado

July, 1966

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I. INTRODUCTION

Request and Authority

The Bureau of Reclamation, Region 6, Department of the Interior, in a letter dated December 21, 1965, requested the Federal Water Pollution Control Administration, Department of Health, Education, and Welfare, to participate in the Bureau's planning of the Sun-Teton Unit as set forth in the Federal Water Pollution Control Act, as amended, (33 U.S.C. 466 et seq.).*

Purpose and Scope

The general objectives of this study are (1) to assess the effects of project construction and operation on water quality in the Sun and Teton Rivers and in the proposed project reservoirs, (2) to ascertain what benefits are achieved or lost from changes in water quality, (3) to assess the suitability of the water for proposed water uses, and (4) to determine the need for and value of streamflow regulation for the purpose of water quality control. The necessity of streamflow regulation was studied not only in light of present conditions but also for anticipated future conditions in the study area to the year 2075. The study area includes the Sun River Basin in Lewis and Clark, Teton, and Cascade Counties and the Teton River Basin in Teton and Choteau Counties.

* Responsibility for these activities has been transferred from the Department of Health, Education, and Welfare to the Department of the Interior in accordance with Reorganization Plan No. 2, effective May 10, 1966.

The conclusions presented must be considered tentative pending completion of the Missouri-Souris Red River Basin Comprehensive Water Supply and Water Quality Management Study being conducted in this region by the Federal Water Pollution Control Administration. The results provided herein are suitable for use in project feasibility determinations.

Acknowledgments

The assistance and the cooperation of State and Federal agencies and individuals are gratefully acknowledged. Particular recognition is expressed to the following for data and advice furnished by their staff members:

Bureau of Reclamation, Region 6
Billings, Montana
and
Upper Missouri River Basin Projects Office
Great Falls, Montana

Geological Survey
Water Resources Division
Branch of Quality of Water
Worland, Wyoming

Fish & Wildlife Service
Bureau of Sport Fisheries and Wildlife
Missouri River Basin Studies
Billings, Montana

Montana Fish & Game Department
Helena and Great Falls, Montana

Montana State Board of Health
Helena, Montana

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Bureau of Reclamation, Region 6, in connection with its Missouri River Basin Project, Sun-Teton Unit, is considering the construction of a dam and reservoir on the Sun River at one of three sites: (1) The Lower Sun Butte Dam and Reservoir would be located immediately below the confluence of the North and South Forks of the Sun River; (2) The Lowry Dam and Reservoir would be located about 5 miles west of Simms, Montana; and (3) The Castle Reef Dam and Reservoir would be located just upstream from the site of the present Sun River Diversion Dam. For either the Lower Sun Butte site or the Castle Reef site, proposed project development includes the diversion of an average of 102,500 acre-feet of water annually to the Sun and Teton River basin for irrigation of new land and supplemental supply for presently irrigated land. The Lowry Reservoir would provide only supplemental irrigation water for lands in the Sun River Basin. Each of the three reservoirs would provide about the same degree flood control but would result in varying degrees of recreation and fish and wildlife uses.
2. This study covers the entire Sun and Teton River Basins. The Sun River Basin is located in Lewis and Clark, Teton, and Cascade Counties; the Teton River Basin is located in Lewis and Clark, Teton, and Choteau Counties. The economic evaluation for this study considered Cascade, Teton, and the northern one-third of Lewis and Clark County.

3. This study area is the largest population center in Montana and has been growing at nearly twice the rate of the United States over the past two and a half decades. Great Falls is the trade, service and transportation center for north central Montana.
4. The major use of water from the Sun and Teton Rivers is irrigation. There are approximately 110,000 acres being irrigated from the Sun River above Vaughn and 44,000 acres are being irrigated from the Teton River above Dutton, Montana. The towns in both basins rely on ground water supplies as sources of domestic supply. Great Falls, Montana, takes its municipal supply from the Missouri River above the confluence of the Sun River.
5. Water quantity data shows the mean annual flow of the Sun River at Vaughn to be 511,300 acre-feet based on 1935-1963 records (ranges: 152,000-946,000 acre-feet/year). The mean annual flow of the Teton River at Dutton is 110,400 acre-feet based on 1954-1964 records (ranges: 40,300-254,300 acre-feet/year). Ground water is not considered a major source of water for agricultural purposes. Ground water aquifers capable of producing over 50 gallons per minute exist only in a narrow band along the lower Sun River.
6. Only meager water quality data are available for the Sun River Basin, while the data for the Teton River Basin are limited to the area around Choteau and Dutton, Montana. It appears that

water quality in the mountainous portions of both basins is good to excellent for municipal, irrigation, and most industrial uses. Although there is a general deterioration in water quality in the Sun River due to irrigation and natural causes, the mineral quality is still satisfactory for most uses. Big Muddy Creek contributes a large silt load to the Sun River near Vaughn. Fish life is practically non-existent in this portion of the Sun River due to the high turbidity. Drainage and/or seepage from the Priest Butte and Fresscut Lake areas is brackish in nature and causes a marked increase in the salinity of the Teton River between Choteau and Dutton. The concentration of total dissolved solids averaged 990 mg/l in the Teton River near Dutton from August, 1955 to October, 1957, however, this quality condition is not amenable to improvement by flow regulation from the proposed storage on the Sun River.

Conclusions

1. Great Falls will continue to be one of the high growth areas in Montana. Future growth in employment is most likely in wholesale and retail trade, services and food and kindred product manufacturing. The population of the rural portion of the study area is not expected to change significantly.
2. The irrigation return flows from the water diverted to the Teton River Basin will increase the mean annual flow of the Teton River below Choteau. The Bureau of Reclamation has not yet determined the magnitude of this increase.
3. The water diverted to the Teton River Basin will be of excellent quality, TDS concentrations of 150 to 200 mg/l, for irrigation. It is anticipated that the quality of the irrigation return flows from this water will be equal to or better than the annual average quality of the Teton River near Dutton.
4. Construction of a reservoir at any of the proposed sites would result in increased TDS concentrations in the Sun River. Although the available data is not sufficient to determine the magnitude of the increase, it is anticipated that the mineral quality of the water would be suitable for all present and projected uses.
5. The Lowry reservoir would not significantly reduce the turbidity in the Sun River below Big Muddy Creek. Control of this problem requires elimination of the turbidity before it enters the Sun River. The most practical solution would be to improve irrigation

practices and initiate other methods of soil conservation so as to keep soil erosion to a minimum.

6. Based on present and anticipated organic waste loadings, dissolved oxygen concentrations in the Sun and Teton Rivers will be sufficient to support fish and aquatic life. The depth of the proposed reservoirs, particularly the Lower Sun Butte and Castle Reef sites, could result in some water quality problems because of thermal stratification and low dissolved oxygen levels at deeper depths. The release of the colder water from the lower level (i.e., at the top of the inactive pool) with generally low dissolved oxygen levels could have adverse effects on downstream fish and aquatic life. One solution to a problem of this nature is to construct a multilevel outlet structure to allow releases to be made from selected depths.
7. At this time no need is foreseen for the inclusion of storage in any of the three proposed reservoirs for the purpose of streamflow regulation for water quality control.
8. The conclusions presented herein are based on what data is available at this time and should be considered as tentative, pending completion of the Missouri-Souris Red River Basins Comprehensive Water Supply and Water Quality Management Study being conducted in this region by the Federal Water Pollution Control Administration. The results provided herein are suitable for use in project feasibility determination.

III. PROJECT DESCRIPTION

The Sun-Teton Unit, Sun-Teton Division, Missouri River Basin Project is located in Lewis and Clark, Teton, and Cascade Counties in northcentral Montana. (See map--Figure I at end of report.) The proposed project includes the construction of a multipurpose dam and reservoir on the Sun River to provide flood control, irrigation, fish and wildlife, and recreation benefits. At present, the following three reservoir sites are under consideration by the Bureau of Reclamation:

1. Lower Sun Butte Site: This site is located on the Sun River immediately below the junction of the North Fork and South Fork of the Sun River. Total storage capacity of the reservoir would be 312,000 acre-feet. (See Table 1.) The Lower Sun Butte Reservoir, along with the existing Gibson Reservoir, would receive runoff from approximately 27 percent (573 square miles) of the water shed in the Sun River Basin; however this would include more than 68 percent of the average natural flow in the Sun River. The Lower Sun Butte site lies within the Lewis and Clark National Forest. The reservoir would have a surface area of about 3,870 acres and would extend into the Bob Marshall wilderness area. The Bureau of Sport Fisheries and Wildlife, Department of the Interior, has recommended that no storage reservoir, diversion, or other facilities for water resources development be built above the existing Gibson Dam because of the adverse effect that would result to fish and wildlife and the wilderness scenery.(1)

Table I

Reservoir Storage Capacities*

Reservoirs

Storage Allocation	Lower Sun Butte		Gibson (existing)		Castle Reef		Lowry	
	1000 AF	Elev. top of pool	1000 AF	Elev. top of pool	1000 AF	Elev. top of pool	1000 AF	Elev. top of pool
Sediment and Inactive	1.6	4,762	0	4,560	4	4,538	60	3,700
Exclusive Conservation Space	150.4	4,928	89.2	4,712	243	4,718	100	3,735
Joint Conservation and Flood Control Space	75.2	-	-	-	75	4,746	100	3,757
Exclusive Flood Control Space	84.8	4,978	15.8	4,724	100	4,780	80	3,771
Total Storage	312	4,978	105	4,724	422	4,780	340	3,771
Approximate Depth at Dam (Maximum)		216'		164'		242'		71'
Approximate Depth of pool at top of Conservation Storage		166'		152'		180'		35'

*Data from Bureau of Reclamation studies. (1,2,3)

2. Castle Reef Site: This site is located on the Sun River just above the existing Sun River Diversion Dam. The reservoir would have a total storage capacity of 422,000 acre-feet including the 105,000 acre-feet of storage in the Gibson Reservoir, which would be inundated by Castle Reef Reservoir. The reservoir would extend into Lewis and Clark National Forest but would not infringe on the lands within the Bob Marshall Wilderness area except when the top of the flood control storage is reached. This maximum water level, however, would be reached infrequently.
3. Lowry Site: This site is located on the Sun River about five miles upstream from Simms, Montana. The reservoir would have a storage capacity of 340,000 acre-feet.

Under proposed project development if either the Lower Sun Butte site or the Castle Reef site is selected, an annual average of 102,500 acre-feet of water would be diverted to the Teton River Basin for the unit lands, consisting of 27,300 acres of new land and 3,700 acres of supplemental service land. About 6,000 acres of the new lands are in the Sun River Basin, and the remainder is in the Teton River Basin. Service would be provided through the enlargement of existing supply canals, the construction of the 28 mile Corson Canal, and Corson Dikes and Reservoir (capacity 40,000 acre-feet), the 25 mile Burton Bench Canal, a diversion works at the point where the Corson Canal would cross Deep Creek, two pumping plants, and an extensive system of

laterals and drains. The main project lands in the Teton River Basin would be located in the Burton Bench area and the Priest Butte Lake area. Water would be supplied to the Burton Bench from the Corson Reservoir via the Burton Bench Canal. The Priest Butte Lake area would receive water via Corson Canal and Deep Creek. Gross diversions would be 3.2 acre-feet/acre and 1.6 acre-feet/acre to newly irrigated and supplementally irrigated land respectively. It is not known how much additional water, if any, would be supplied for irrigation in the Sun River Basin if either the Lower Sun Butte site or Castle Reef site is selected.

If the Lowry site is selected there would be no diversions to the Teton River Basin. However, replacement irrigation service would be supplied from Lowry Reservoir to the Fort Shaw Division and downstream private lands in the Sun River Basin and Gibson Reservoir would serve some additional acreage on the Greenfields Division. The Lowry Reservoir would provide more recreation benefits than either of the other two reservoirs because of its proximity and easier accessibility to Great Falls, the major population concentration in the area; it would, however, have less fishing and irrigation benefits than either of the other two reservoirs.

The Fish and Wildlife Service has requested that a minimum flow of 270 cfs be supplied to the river below Sun River Diversion Dam. This release, if granted, would be made from the Lower Sun Butte or Castle Reef sites if either of these sites are chosen or from Gibson Dam if the Lowry Dam is constructed. The Bureau of Reclamation

operation study for the Castle Reef site for 60 years of record (1904-1964) shows that this request for 270 cfs could be met 83-87% of the time during June, July, and August but only 55-65% of the time during September through May. The maximum release that would be made for fishery purposes during dry years would be 100 cfs (3). The Montana Fish and Game Department is primarily concerned with the effect of project construction on fishing benefits between the Sun River Diversion Dam and the Lowry site. (4)

IV. STUDY AREA DESCRIPTION

For this study, the entire Sun River Basin and that portion of the Teton River Basin located in Teton and Lewis and Clark Counties were considered. The headwaters of both rivers rise on the eastern slopes of the Rocky Mountains which form the Continental Divide. The Sun River flows in an easterly direction emptying into the Missouri River at Great Falls. The Sun River Basin has a drainage area of approximately 2,000 square miles; one-third of which is timbered mountains. The basin is about 80 miles in length and 25 miles in width. (1) Elevations range from 3,300 feet at Great Falls to more than 9,000 feet near the headwaters.

The Teton River also flows in an easterly direction emptying into the Marias River near Loma, Montana, about three miles upstream of the confluence of the Marias and Missouri Rivers. Loma (not shown on map-figure 1) is 51 miles northeast of Great Falls. There are about 1,955 square miles of drainage in the Teton River Basin. The basin is about 120 miles long with a maximum width of 30 miles. Ranges of elevation are from 2,500 feet in the plains area to 8,865 feet in the mountainous area.

The topography of the Sun River Basin consists of mountains, rolling foothills, and high benches. The topography of the Teton River Basin varies somewhat from the Sun River Basin in that there is a marked absence of foothill development; instead there is an abrupt change from mountains to plains.

A study of the geology of the Sun and Teton River Basins indicates that the area is underlain by Cretaceous strata which has been moderately folded and faulted by the same forces that elevated the Rocky Mountains. A large portion of eastern Teton County and northeastern Cascade County is underlain by shale which in some cases lies close to the surface. This results in a poorly drained landscape. The eastern portions of these two basins were covered with a continental glacier which gave them their present rolling condition. Parts of the western portion were covered by alpine glaciers which left terminal and lateral moraines. Shale and sandstone deposits are exposed in parts of the old lake bed of the glacial lake that formed between the alpine glaciers and the continental ice cap. Gravel terraces and late deposited silts and clays are common in the rest of this area. (5,6)

The climate of the area is classified as continental. The summers are generally warm, with the high temperatures averaging about 80° in the area around Choteau, with somewhat cooler temperatures prevailing in the mountains. Winters are generally cold, with temperatures of -35°, -46°, and -50°F having been recorded at Great Falls, Sun River, and Choteau respectively. However, the occurrence of Foehn (locally known as Chinook) Winds during the winter has the effect of shortening the duration of cold spells and causing snow to melt.

Precipitation varies considerably from the mountainous western edge to the plains area. Choteau has an average annual precipitation of 11.5 inches; Great Falls averages 14 inches. About 75% of the

precipitation occurs during the growing season from May through September. Some mountainous areas have precipitation as high as 60 inches. (7,8,9)

The main population center in the area is Great Falls (metropolitan population - 76,000) located at the mouth of the Sun River. Choteau, (population 1,966) is the county seat of Teton County and the largest town in the Teton River Basin. The towns of Augusta (400), Vaughn (265), Fairfield (752), and Dutton (504) are other population centers.

The main industry in the study area is the production and sale of agricultural products.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water

In the Sun River and Teton River Basins, streamflows at the higher elevations are derived from snowmelt and spring rainfall. Streamflows are generally highest during May and June and at their lowest September through March. Natural accretions and irrigation return flows account for a large portion of the late summer flows. The Sun River at Sun River Diversion Dam has a mean annual flow of 622,000 acre-feet based on 60 years of record, 1905-1964. The reservoir operation studies for the period 1935-54 show a mean annual flow of 612,000 acre-feet which compares closely with the 60-year record. Since there is a variation in the length of flow records in the Sun River Basin, the period 1934-63 was used at all stations for comparison purposes. Where additional flow records were available, the mean annual and mean monthly flows were calculated for the total period and also for the 1934-63 period (see Table II). The mean annual flow at the Sun River Diversion Dam for this period is 609,200 acre-feet. The Sun River at a gauging station near Vaughn, which is below the mouth of Big Muddy Creek, has a mean annual flow of 511,300 acre-feet for the period of record 1934-63.

It is evident that, on an average basis, there is an annual depletion of 97,900 acre-feet between the Sun River Diversion Dam and Vaughn. Table II shows the average monthly flows of surface waters at various locations in the study area. From a comparison of the

TABLE II

Quantities of Surface Water in the Study Area^{1/} (000 AF)

Location of Station	Period of Record	Range	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Annual
Sun River at Lower Sun Butte Site ^{2/}	Oct. 1924 Sept 1963	Max	35.4	41.4	39.1	26.0	20.9	31.4	178.0	327.0	322.9	135.3	41.3	28.3	843.7
		Min	4.7	5.1	4.8	5.3	4.7	4.6	8.6	58.9	44.1	17.9	11.9	3.1	233.6
		Avg.	16.0	13.7	12.9	10.8	9.7	11.4	37.2	155.5	159.5	54.4	21.3	15.6	518.0
Sun River at Lower Sun Butte Site ^{3/}	Oct. 1934 Sept 1963	Max	35.4	29.3	23.1	19.6	16.2	18.5	68.1	241.7	322.9	135.3	41.3	28.3	763.4
		Min	8.6	5.7	4.8	5.5	4.7	4.6	8.6	58.9	54.1	18.9	11.9	9.2	233.6
		Avg.	16.3	13.5	13.0	11.0	10.0	11.3	31.2	151.9	163.7	57.7	22.1	16.0	517.8
Sun River at Sun River Diversion Dam	Oct. 1904 Sept 1964	Max	41.6	48.7	46.0	32.0	24.6	37.0	209.6	385	467	267	60.4	42.5	1173.4
		Min	5.5	6.0	5.6	5.9	5.8	5.4	10.1	68.8	51.9	16.3	11.2	3.6	274.5
		Avg.	18.6	16.7	14.9	12.9	11.7	13.6	41.6	174	203.4	70.3	26.2	18.7	622.6
Sun River at Sun River Diversion Dam	Oct. 1934 Sept 1963	Max	41.6	34.5	27.2	23.1	16.3	21.8	80.1	284.3	379.9	159.3	48.6	33.3	898.1
		Min	10.1	6.7	5.6	6.5	5.5	5.4	10.1	69.3	63.7	22.3	14.0	10.8	274.5
		Avg.	19.2	15.8	15.3	12.9	11.7	13.3	36.7	178.7	192.6	68.0	26.1	18.8	609.2
Sun River at Castle Reef Site	Same as Sun River at Sun River Diversion Dam														
Sun River near Vaughn	Oct. 1934 Sept 1963	Max	47.9	37.1	38.0	30.4	27.1	47.6	122.5	222.6	471.7	124.7	62.8	42.0	946.3
		Min	8.8	8.9	7.0	4.1	4.7	8.2	5.6	5.4	16.7	16.3	15.4	9.8	152.0
		Avg.	22.1	18.7	17.5	14.0	13.1	18.9	28.5	106.7	164.3	49.1	33.6	24.6	511.3
Big Muddy Creek near Vaughn	Oct. 1934 Sept 1963	Max	12.3	4.6	8.0	4.1	5.6	8.9	5.2	18.8	28.6	21.2	23.5	13.8	122.5
		Min	2.9	2.6	1.2	1.1	0.6	1.4	1.5	3.2	5.1	4.8	7.5	4.1	44.4
		Avg.	6.2	3.6	2.8	2.1	2.0	3.4	2.3	7.6	12.3	13.9	16.3	10.4	82.3
Teton River near Dutton	Aug. 1954 Sept 1964	Max	6.3	8.4	12.8	4.7	14.8	22.9	16.8	34.4	162.3	33.9	10.8	8.5	254.3
		Min	1.7	1.8	1.9	1.6	2.0	2.9	3.7	2.8	6.6	2.7	1.5	1.5	40.3
		Avg.	4.0	4.4	4.6	3.2	4.4	8.4	7.3	17.0	33.9	13.6	5.2	4.0	110.4

^{1/} Data

Source: U. S. Geological Survey and Bureau of Reclamation Studies. (1,10,11,12).

^{2/} The flows at Lower Sun Butte Site were assumed to be 85% of flows of Sun River at Diversion Dam by Bureau of Reclamation.^{3/} Flows at the Lower Sun Butte and the Diversion Dam are also shown for period of October 1934 to September 1963 to correspond with data available for the Sun River at Vaughn for the same period.^{4/} The Castle Reef site is about 500 feet upstream from the diversion dam.

monthly flows of the Sun River at the Diversion Dam and near Vaughn it appears that most diversions are taking place April through July. (Approximately 110,000 acres are irrigated above Vaughn.)

The two largest irrigation projects using water from the Sun River at present are the Greenfields Division (77,640 productive acres) and the Fort Shaw Division (9,970 productive acres). Water is diverted at the diversion dam to Piskun Reservoir near Piskun canal; it is then supplied to the Greenfields Division via a series of canals and lateral (See Figure 1 at the end of this report). The gross diversion for the Greenfields acreage averages 3.2 acre-feet per acre or 248,400 acre-feet per season. The total amount of water diverted to Piskun Reservoir is 261,500 acre-feet, the difference of 13,100 acre-feet being attributed to channel losses in Piskun Canal. Water for the Fort Shaw Division is diverted directly from the Sun River to the Fort Shaw Canal. The gross average diversion is 5.7 acre-feet per acre or 56,800 acre-feet per season. Irrigation of private lands along the Sun River requires about 29,700 acre feet per season. The present operating procedure is to release 300 cfs past Sun River Diversion Dam at the beginning of the irrigation season. Releases are made from the Willow Creek Reservoir during the season to maintain the 300 cfs flow. The natural accretions, return flows, and the above releases satisfy the demands of the Fort Shaw Division and private irrigators. A similar procedure will be followed with the reservoir at the Lower Sun Butte or Castle Reef sites.(1)

Table II shows the maximum, minimum and mean monthly flows for Big Muddy Creek, a tributary of the Sun River near Vaughn. Big Muddy Creek receives the return irrigation flows from the Greenfields Division. Comparison of the mean monthly flows for July and August at all stations in the Sun River Basin shows that these are the high flow months for Big Muddy Creek, whereas at all other stations May and June are the highest flow months.

There are only limited flow records available for the Teton River Basin. Table II shows the monthly flows near Dutton for August 1954 through September 1964. The average annual flow is 110,400 acre-feet with the highest flows occurring in May and June. Diversions for irrigation of approximately 44,000 acres are made from the river above this station.

Quality of Water

A summary of the available published water quality data for surface waters in the Sun River and Teton River Basins is given in Table III. In addition, conductivity readings taken during a field investigation in April, 1966 are given in Table IV. The data for the Sun River Basin is very meager, consisting of six individual grab samples plus the conductivity readings. This data indicates that in the mountainous portion of the Sun River Basin the water quality is good to excellent for municipal, industrial, and agricultural uses. The Montana Fish and Game Department stated that the mineral content of the water in the upper

TABLE III
QUANTITY OF SURFACE WATERS IN STUDY AREA^{1/}

Description of Station	No. & Type of Samples	Flow (cfs) Range	pH	Residual @ 25°C (mbars)	Ca	Mg	Na	KCO ₃	SO ₄	Cl	B	Hard @ 25°C	TDS	BAR	D.O.
1. Gibbon Reservoir (8/21/51)	1 Grab	-	8.0	220	32	8.0	1.8	130	8.0	0.5	-	113	132	0.07	-
2. Sun River Reservoir Dam (8/21/51)	1 Grab	-	7.9	237	40	7.8	3.2	149	13	1.0	-	132	132	0.12	-
3. Fishum Reservoir (8/21/57)	1 Grab	-	7.9	236	38	9.2	2.1	146	16	0.5	-	133	156	0.08	-
4. Sun River about 1 mile below Sun River Diversion Dam NM 2252.2/63 (8/27/56)	1 Grab	-	8.4	-	-	-	-	-	17	0	-	161	-	-	9.0
5. Sun River near Augusta NM 2252.2/63 (8/27/56)	1 Grab	-	8.4	-	-	-	-	-	61	6	-	190	-	-	8.6
6. Sun River about 10 miles above Vaughn NM 2252.2/29 (8/27/55)	1 Grab	-	8.4	-	-	-	-	-	164	4	-	301	-	-	8.2
7. Teton River about 1 mile south of Choteau NM 2181/1.5/129 (8/10/59)	1 Grab	-	8.2	-	-	-	-	-	44	4	-	272	-	-	8.2
8. Teton River below Choteau NM 2181/1.5/127 (8/26/56)	1 Grab	-	8.4	-	-	-	-	-	46	4	-	239	-	-	8.5
9. Teton River about 4 miles east of Choteau NM 2181/1.5/122 (8/26/56)	1 Grab	-	8.6	-	-	-	-	-	425	23	-	408	-	-	8.1
10. Teton River above confluence 2181/1.5/0.5 (8/10/59)	1 Grab	-	8.5	-	-	-	-	-	348	14	-	374	-	-	7.6
11. Teton River ^{2/} below Choteau on Highway 89 2181/1.5/127 (8/2/55-10/1/57)	29 Grab Samples	Max 682 Min 29 Avg 524	8.3 7.7 -	682 406 524	67 29 55	33 19 25	41 12 21	316 213 265	118 36 63	9.0 0 1.7	0.11 0.03 0.05	289 185 240	431 226 306	1.1 0.4 0.6	-
12. Priest Butte-Lake Drain Greenfield Lake ^{3/} 2181/1.5/127 (8/2/55-10/1/57)	23 Grab Samples	Max 17,000 Min 50 Avg 10,550	9.1 7.7 -	17,000 3,720 10,550	493 50 185	1,480 237 781	2,960 192 1,877	538 158 394	12,700 2,860 6,770	431 14 265	2.50 0.46 1.4	6,480 3,170 3,495	16,600 3,410 9,960	18 1.7 14	-
13. Teton River northeast of Butte (8/24/54-9/30/57)	Composite Samples	Max 841 Min 32.3 Avg 144	8.4 7.7 -	5,320 446 1,360	123 41 67	412 25 74	548 29 139	413 210 302	3,230 113 488	69 3 16	0.54 0.04 -	1,970 226 471	5,190 320 990	8.0 0.8 2.8	-

^{1/} Data for stations 4-7 taken from Montana State Board of Health Publication, stations 1-3 and 8-10 from U.S.G.S. data (13,14).
^{2/} Stations 8 and 11 are the same.
^{3/} Greenfield Lake is now known as Priest Butte Lake.
^{4/} Concentrations of chemical constituents are flow weighted; flow is time weighted.

TABLE IV

CONDUCTIVITY MEASUREMENTS IN THE SUN & TETON RIVER BASINS ^{a/}

<u>Sun River</u>					
<u>Date</u>	<u>Time</u>	<u>Temp.</u>	<u>ECx10⁶ umhos/cm</u>	<u>Flow</u>	<u>Location</u>
4/6/66	1100	5°C	290	220	about 400' above diversion dam
"	1400	10°C	400	220 (est.)	Highway U.S. 287
"	0930	7°C	420	250 (est.)	Lowry site
"	1725	10.5°C	630	280 (est.)	near Vaughn
"	1745	10°C	700	300 (est.)	at confluence
<u>Muddy Creek</u>					
4/6/66	1700	13°C	1540	20CFS	at Vaughn
<u>Willow Creek</u>					
4/6/66	1230	9°C	600	?	above Willow Creek Reservoir
<u>Teton River</u>					
4/6/66	1445	7.5°C	420	flow increasing downstream	adjacent to Zureka Lake
4/6/66	1535	10°C	540	"	Highway U.S. 89
4/6/66	1605	9.5°C	1650	"	Highway 221

^{a/} Data collected during a field investigation of the Sun and Teton River Basins

reaches of the Sun River is too low to maintain a productive fishery; however, it becomes better suited for this purpose downstream towards Gibson Reservoir. Although there is a steady increase in mineral concentrations with increasing distance downstream, the mineral quality appears suitable for most uses.

Big Muddy Creek and the Sun River below Big Muddy Creek are highly turbid throughout most of the year. The Montana Fish and Game Department has stated that fish life is practically non-existent in this portion of the Sun River due to the high turbidity.(4) Water quality data for the Teton River Basin is limited to the plains portion of the basin. Upstream from Choteau the water quality appears to be similar to that of the Sun River. Downstream from Choteau water quality is influenced by drainage from Priest Butte Lake, Freezeout Lake, and the surrounding areas. Samples collected from the drain from these lakes had an average total dissolved solids (TDS) concentration of about 10,000 milligrams per liter (mg/l). For the Teton River near Dutton the flow weighted concentration of TDS was 990 mg/l, with a maximum concentration of over 5,000 mg/l.

Available data indicates that dissolved oxygen (D.O.) concentrations are greater than 7 mg/l in the Sun River and Teton River. This is to be expected considering the stream gradients and the small organic waste loadings in these streams.

Ground water is not considered a major source of supply for irrigation in the Teton or Sun River Basins. A narrow ground water aquifer exists along the lower Sun River which is capable of producing

Table V

Water Quality of Selected Municipalities in the Study Area^{1/}

Town	Location (County)	Source of Supply	Date of Sample	Total Solids	Hard- ness	Ca	Mg	CO ₃	HCO ₃	Cl	SO ₄	Na+K	Fe	F	NO ₃	Pb	Cu	As ₂ O ₃
Choteau	Teton	Springs & well	9/60	270	270	68	24	0	275	0	47	4	<0.1	0.1	0	0	0.2	0
Dutton	Teton	Well	10/60	960	593	140	60	0	329	16	461	83	2.7	0.5	0	-	-	-
Fairfield	Teton	3 wells	8/61	350	360	26	72	0	378	3	37	0	0	0.9	11	-	-	-
Great Falls	Cascade	Missouri River	1/59	300	250	43	35	0	183	10	64	0	0.16	1.0	0.6	0	0	0

^{1/} Source: Montana State Board of Health (15).

50 to 500 gpm, however, in the remainder of the basin ground water yield is less than 50 gpm. Most municipalities in the study area have wells as sources of domestic supplies. Table V shows the available water quality and sources of supply for selected municipalities in the study area.

The area east of Choteau and Fairfield is underlain by Colorado shale which is a poor source of ground water. Wells are both shallow and deep. They are shallow when the water can be obtained from alluvial fills, terrace gravels, or the thick unconsolidated cover. The wells are deep, when water cannot be obtained from the above sources. It is then necessary that the wells be drilled into the lower part of the Colorado Group or into the Kootenai Formation (7,8,9). Highly mineralized water (TDS 3,000 mg/l) has been encountered in some areas of Teton and Choteau County at both shallow and deeper depths.

VI. THE ECONOMY

To efficiently develop the water resources for competitive uses and effectively supply the present and projected needs of the study area, the past, present and future economic conditions were investigated. The projected economic development is the basis of the future waste loads on which quality control requirements are determined.

The City of Great Falls dominates the economy of the study area (counties of Cascade, Teton and northern one-third of Lewis and Clark county). Great Falls is a trade and service center for the surrounding area of north central Montana. Trade is the largest employer in the study area. Manufacturing is the second largest employer. The largest manufacturing industry is the Anaconda Company smelter, which reduces zinc and copper ore to the basic metals and manufactures wire and cable. The location of this industry is related to the availability of hydroelectric power generated at the series of rapids and falls on this stretch of the Missouri River. Food and kindred products, largely flour milling and meat packing are other established, important industries. Defense Department activities in the form of a nearby air base and missile sites are important to the economy.

Dry land wheat farming predominates in the agriculture of the area. Livestock and livestock products provided only forty percent of the value of farm products in the area in 1959. There are nearly 120,000 irrigated acres in the area which are mostly used to produce feed, but sugar beets, peas, grain and potatoes are also grown.

Great Falls is a transportation center for western Montana. There are two railroads, four scheduled airlines, two bus lines and nine or ten truck lines. Three U. S. Highways, including one interstate highway, intersect at Great Falls.

The area has considerable recreation potential. It is 200 miles from Yellowstone National Park and 150 miles from Glacier National Park. In addition, there are other attractive mountain areas close by. Local demand for recreation will increase as the Great Falls metropolitan area grows.

Table VI shows the components of employment change in the study area. The National Growth column indicates what the growth in the area and each of its industries would have been had they grown at the average rate of growth for all industries in the United States. The smaller total in this column compared to the actual change in employment in the area in 1950-60 indicates that employment in the study area grew faster in this period than employment in the United States as a whole. A comparison of 1940-50 figures and 1950-60 figures shows that the area grew faster in relation to the growth of the entire United States in both periods, but particularly from 1950-60.

The Industry Mix column separates out the amount of employment that devolved from the particular industrial structure of the area (i.e., an area with a preponderance of fast growth industries would prosper accordingly). The negative figure here for 1950-60 indicates an unfavorable industrial composition. A major factor in this condition is the large share of employment in agriculture as well as railroad

TABLE VI
Components of Employment Change

Industry	1940	Employment 1950	1940-50 Change	1940-50 Net'l Growth	1940-50 Indus- trial Mix	Reg- ional Share	Net Rel. Change	1950-60 Change	1950-60 Net'l Growth	1950-60 Indus- trial Mix	Reg- ional Share	Net Rel. Change
Agriculture (Forest. & Fish.)	3,532	3,524	2,661	-8	893.17	-1512.93	-901.19	-863	526.31	-1862.15	472.82	-1389.33
Mining	565	143	125	-422	142.88	-133.26	-564.88	-18	21.36	-63.70	24.34	-39.36
Construction	872	1,614	2,200	742	220.51	352.89	168.59	566	241.05	-64.64	409.58	344.94
Manufacturing	2,494	2,978	3,330	484	630.68	315.14	-461.84	332	444.76	153.34	-248.13	-92.77
Furniture & Lumber & Wood Prods.	32	52	55	20	8.09	2.03	9.87	3	7.77	-13.09	8.32	-4.77
Primary Metal	1,508	1,787	1,359	279	381.34	131.03	-233.38	-428	266.89	190.87	-885.76	-694.89
Fabricated Metal Industries	41	52	32	11	10.37	3.56	-2.93	58	7.77	5.55	-33.32	-27.77
Machinery except electrical	56	57	115	1	14.16	29.98	-43.14	40	1.34	6.62	32.04	34.66
Electrical Mech., Equip. & Spis.	-	9	49	9	5.56	5.88	-22.56	11	.75	-.90	11.15	10.25
Motor Vehicles & Equipment	22	5	16	17	.25	.32	14.36	16	.15	.89	14.96	15.85
Trans. Equipment except Motor Vhs.	1	1	17	-0-	.25	.32	14.36	83	10.75	4.35	67.90	72.25
Other Durable Goods	46	72	155	26	11.63	11.77	6.30	284	79.60	81.70	122.70	204.40
Food & Kindred Products	411	533	817	122	103.93	11.77	-2.01	16	.45	-1.14	-2.31	-3.45
Textile Mill Products	4	3	-	-1	1.01	.77	-1.24	-3	1.34	-.53	2.19	1.66
App'l & Other Fab. Textile Prod.	10	9	12	-1	2.53	1.01	-4.54	3	1.34	58.32	176.38	234.70
Printing, Publ. & Allied Prods.	246	310	591	64	62.21	21.67	-19.88	281	46.30	3.42	-23.55	-20.13
Chemical & Allied Products	7	21	4	14	1.77	2.05	10.18	-17	3.14	-4.19	35.19	31.00
Other Non-durable Goods	110	67	108	-43	27.82	-6.42	-65.50	41	10.01	-71.92	-55.67	-753.78
R & Railway X Service	1,031	1,485	953	454	260.72	-33.03	226.30	-532	221.78	-698.11	41.19	-12.82
Trucking Service & Whrsing.	129	272	341	143	32.62	21.44	88.94	69	40.62	41.19	-12.82	28.37
Other Transportation	134	247	198	113	33.89	37.68	41.44	-49	36.89	-27.36	-58.53	-85.89
Communications	112	199	592	87	28.32	55.72	2.96	393	29.72	23.88	339.40	363.28
Utilities and San. Service	322	416	340	94	81.43	51.87	-39.30	-76	62.13	-.05	-136.08	-136.13
Wholesale Trade	639	984	1,140	345	161.59	247.37	-63.96	156	146.96	-28.85	37.68	9.03
Food & Dairy Products Stores	496	553	742	57	125.43	-49.43	-19.00	189	82.59	-91.55	197.96	106.41
Eating & Drinking Places	582	1,073	1,083	491	147.18	151.40	192.43	10	160.25	-86.30	-63.8	-150.26
Other Retail Trade	1,842	2,568	3,260	726	465.80	239.33	20.85	692	383.53	73.32	235.15	308.47
F.I.R.E.	588	804	1,323	216	148.69	28.54	38.76	519	120.08	206.52	192.40	390.92
Business & Repair	369	711	626	342	93.31	122.25	126.43	-85	106.19	-5.75	-185.44	-191.19
Private Households	415	274	849	-141	104.94	-228.40	-245.95	575	40.92	6.39	527.69	534.08
Other Personal Services	721	837	982	116	182.33	-92.19	25.86	145	125.00	-85.42	105.41	19.99
Entertainment & Recr. Services	144	253	272	109	36.41	9.75	62.83	19	37.78	-61.14	42.36	-18.78
Educational Services	537	780	1,336	243	135.80	39.15	68.05	556	116.49	383.80	55.71	439.51
Medical & Other Prof. & Related	1,078	1,375	2,120	297	272.60	273.50	-249.10	745	205.36	626.46	-86.83	539.63
Public Administration	630	1,123	1,225	493	159.31	325.48	8.20	602	167.72	154.50	279.77	434.27
Ind. not Reported	306	309	655	3	77.38	-30.26	-44.13	346	46.15	604.34	-304.49	299.85
Total Employment	17,538	22,522	26,853	4,984	4,344.99	192.01	356.88	4,331	3,363.64	-799.26	1,766.52	947.26

Source: U. S. Census of Population

transportation. The area benefits from faster growth industries in Manufacturing, mostly Primary Metals, Food and Kindred Products, and Printing and Publishing and in some services.

The Regional Share indicates the degree to which particular industries in this area grew faster or slower than the same industries did in the United States generally. The study region gained employment in this respect which indicates that it has a competitive advantage in some economic activities. This appears to be the case in Agriculture, Construction, Communications, Personal Services and Public Administration. In manufacturing, however, the area appears to be at a competitive disadvantage, which is most marked in the area's largest industry, Primary Metals. The manufacture of Food and Kindred Products and Printing and Publishing do show a somewhat greater increase in employment in this region than in the United States generally and hence a competitive advantage.

The Net Relative Change shows the change in the area's position relative to the United States. The positive number means that this area has increased its share of national employment. It did this in both the 1940-50 and 1950-60 decades. Future growth in employment is most likely in Wholesale and Retail Trade, Services and Food and Kindred Products manufacturing.

Table VII indicates that the population of the area has grown at three times the rate of the state of Montana and nearly twice the United States rate in the past twenty years. This growth was largely

in the City of Great Falls (and the lesser city of Choteau) with the surrounding non-urban portion of the area growing at a much slower rate. It is anticipated that the rate of growth in the area will slow to two-thirds of its present rate by 1980 and to half the present rate by the year 2000, with Great Falls continuing to grow at a faster rate than the surrounding area. Population projections are shown in Table VII.

Table VII

	Population Trend					Percentage Change		
	<u>1930</u>	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1930-40</u>	<u>1940-50</u>	<u>1950-60</u>	<u>1940-60</u>
Cascade County	41,146	41,999	53,027	73,418	2.1	26.3	38.4	74.8
Great Falls	28,822	29,925	39,214	55,357	3.8	31.1	41.2	85.0
Teton	6,068	6,922	7,232	7,295	14.1	4.5	0.9	5.4
Choteau	926	1,181	1,618	1,966	27.5	37.0	21.5	66.5
Lewis and Clark Co.	858	826	733	992	-3.7	-4.3	35.3	20.1
Northern 1/3 only								
Study Area	48,072	49,747	60,992	81,705	3.5	22.6	34.0	64.2
Montana					4.0	6.0	14.0	20.6
United States					7.0	14.0	18.0	35.7

Source: U. S. Census of Population

Population Projection

	<u>1980</u>	<u>2000</u>	<u>2030</u>	<u>2050</u>	<u>2070</u>
Study Area	120,000	160,000	200,000	242,000	300,000
Great Falls	85,000	130,000	165,000	205,000	240,000

VII. WATER QUALITY CONTROL

Sources of Pollution

Four possible sources of pollution^{a/} were investigated in the study area to determine their effects, if any, on water quality in the Sun and Teton River Basins. These four--municipal, industrial, agricultural, and natural sources--are discussed below:

1. Municipal. There are no towns in either the Sun or Teton River Basins discharging untreated municipal wastes to the rivers. Choteau, Fairfield, and Vaughn have lagoons which provide adequate treatment (20). Augusta, Simms, Sun River, and Farmington have individual septic tanks with sub-surface disposal.
2. Industrial. There are no known or anticipated sources of industrial pollution in the study area which could effect proposed water uses.
3. Agricultural. The main effect of irrigated agriculture on water quality is the increase in salt concentrations due to the evapotranspiration losses of water and the leaching of additional salts from the soil. The available water quality data for the Sun River and Teton River Basin area are not sufficient to determine what effects existing irrigation developments have on water quality in these basins.

^{a/} Water is said to be polluted when its character is changed by the addition of materials, or in any other manner, in such a way that the usefulness of the water is reduced. (19)

Big Muddy Creek is contributing a large sediment load to the Sun River at Vaughn. The greatest share of this sediment load is probably due to runoff from irrigated lands (e.g., the Greenfields Division). The amount of the sediment and TDS load in Sun River below Vaughn that is actually contributed by Big Muddy Creek is not known since there is a complete lack of water quality data for this tributary.

4. Natural Causes. Natural causes of pollution in the study area can be attributed primarily to drainage from areas underlain by shale. The drainage and/or seepage from Priest Butte Lake and Freezeout Lake area is a prime example of this. The Teton River below Choteau shows a water quality with calcium and bicarbonate as the main ions whereas the Teton River northeast of Dutton shows high concentrations of sodium and sulfate.

The flows in Big Muddy Creek are primarily made up of irrigation returns; however, there is also natural drainage through soil underlain by shale beds which are sometime close to the surface.

Water Quality Criteria

Dissolved oxygen, dissolved minerals, and turbidity were the major water quality criteria considered in this study. Adequate concentrations of dissolved oxygen are necessary for maintaining fish

life and for preventing the formation of nuisance conditions (such as odiferous gasses) which generally occur under anerobic or near anerobic conditions. A minimum dissolved oxygen content of 5 mg/l should be adequate for maintaining the fisheries, trout primarily, in the Sun River. The Montana Fish and Game Department stated that flows in the Teton River are too erratic to maintain a suitable fishery.

The suitability of water for irrigation is partially dependent on the concentrations of dissolved minerals. The concentrations at which individual mineral constituents and total dissolved solids affect crop yields are variable, being dependent on such factors as the type of plant, the type of soil, climatic conditions, irrigation practices, and drainage conditions. Many plants cannot tolerate boron concentrations of more than 1 mg/l in irrigation water. The relative concentrations of sodium to that of calcium and magnesium (SAR - Sodium Adsorption Ratio) is important when the water is used to irrigate clayey soils. If the proportion of sodium to calcium and magnesium is high, the alkali hazard is high; if calcium and magnesium predominate, the alkali hazard is low. High concentrations of dissolved salts (in this case total dissolved solids) can have a detrimental effect on plants. Generally, TDS concentrations up to 2,150 mg/l are considered suitable for most plants except the salt sensitive ones. A concentration of 3,150 mg/l is considered by some as the maximum concentration for the safe watering of any plant, provided that drainage and leaching are adequate. (21)

Turbidity is attributable to suspended and colloidal matter. It can affect fish adversely by making it difficult for them to locate food; by decreasing the productivity of fish food, i.e., other aquatic life; and it becomes lethal at very high concentrations. It is also undesirable in waters which are to be used for domestic and industrial purposes. (21)

Flow Regulation

Dissolved oxygen concentrations are well above the desired minimum level in both the Sun and Teton Rivers if the available data as presented in Table III can be considered representative. No dissolved oxygen problems are expected in the rivers under anticipated conditions. Table I shows the maximum depths^{a/} of the three proposed reservoirs and of Gibson Reservoir from the top of the flood control pool; it also shows the depths of the reservoirs from the top of the conservation pool. Impoundments have a tendency to become stratified due to differences in density as a result of temperature variations, e.g., the water in the bottom depths is colder and denser. The dissolved oxygen content at deeper depths is generally much less (at times even zero) than that near the surface (22,23,24). When water is released from the deeper depths it is possible for it to be at low dissolved oxygen levels and at low temperatures. (Maximum density occurs at about 4°C.) The effects of this water downstream may be harmful to fish and other aquatic life by slowing down or even halting their productivity. One means of controlling the temperature and D.O. levels of reservoir

^{a/} All depths given in Table I are measured from the top of the sediment and inactive pool to the top of the storage pool in question, e.g., flood control pool.

releases is to construct a multilevel outlet system to enable water to be drawn from levels selected to maintain acceptable quality rather than only near the bottom of the conservation pool where quality may be poor. This is particularly true with the Castle Reef and Lower Sun Butte sites which would have maximum pool depths of approximately 242' and 216' respectively or conservation pool depths of 180' or 166' respectively (Table I). Lowry Reservoir would only be 71' and 35' deep at maximum depth and the depth of the conservation pool respectively, thus the necessity for a multilevel outlet structure would not be as great.

The water from the Sun River can be considered excellent in quality for the intended project uses of irrigation, fishing, and recreation. The Teton River near Dutton has high concentrations of TDS caused mainly by geologic influences, e.g., the drainage and/or seepage from the Priest Butte Lake and Freezeout Lake areas. This natural source of pollution cannot be controlled. It is possible that a transbasin diversion project, i.e., the reservoir and dam at the Lower Sun Butte or Castle Reef sites, would better the quality of the Teton River below Choteau since there would be an increase in the flows of the river as a result of irrigation return flows; providing, of course, these return flows are of a better quality than the Teton River near Dutton, i.e., the average TDS concentration of return flows should be less than 990 mg/l (See Table IV, Station 13.)

Construction of a dam and reservoir at the Lower Sun Butte site or the Castle Reef site would result in a diversion of 102,500 acre-feet from the Sun River Basin to the Teton River Basin. Consequently, the average annual flow of the Sun River would be depleted by this amount. The average annual flow at Vaughn would be 408,800 acre-feet instead of 511,300 feet and where Big Muddy Creek is now contributing 16 percent or 82,300 acre-feet to the annual flow of the Sun River, it would then be contributing 20 percent of the annual flow with no decrease in either its sediment or TDS load. As a result, turbidity and salt concentrations in the Sun River below the mouth of Big Muddy Creek would increase. This increase in turbidity and salt load should not impair water quality to the extent that it would be unsuitable for irrigation purposes; however, its use for municipal, industrial, or maintaining aquatic life would be further adversely affected.

Construction of the Lowry Dam and Reservoir would aid in decreasing the sediment load in the Sun River at that point and it would not cause the large depletion in the annual flow of the Sun River. However, the benefits to be derived from a dam and reservoir at the Lowry site would have to come from flood control, recreation, and fishing since irrigation benefits would be minimal. The Lowry Reservoir would remove much of the turbidity in the Sun River just above Big Muddy Creek. However, it is doubtful that it would reduce turbidity by any significant amount below Big Muddy Creek. About the only realistic method of controlling this problem would be to eliminate as much of the turbidity as possible before it enters the Sun River. Improved irrigation

practices and other methods of erosion control would undoubtedly eliminate much of the turbidity at the source. It is doubtful if streamflow regulation from Lowry Reservoir would be of much value for reducing turbidity in the Sun River below Big Muddy Creek.

Available data does not allow any quantitative predictions of water quality in the Sun River for any of the three proposed sites. It is assumed that the flow in the Sun River below the diversion dam will remain suitable for its intended use--that of irrigating the Fort Shaw Division and downstream private lands. The releases made from Lowry, if it is constructed, will have some increase in TDS concentrations over that of the inflows to the reservoir; however, it will still be very well suited for irrigation purposes.

Based on the foregoing reasons, additional storage is not recommended in any of the proposed reservoirs for the purpose of providing streamflow regulation for water quality control.

The conclusions presented must be considered tentative pending completion of the Missouri-Souris Red River Basin Comprehensive Water Supply and Water Quality Management Study being conducted in this region by the Federal Water Pollution Control Administration. The results provided herein are suitable for use in project feasibility determinations.

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